CA2 ALEN 28
1971167

ALBERTA LEGISLATURE LIBRARY
3 3398 00206 9309

LEGISLATURE LIBRARY
OCT 29 1974
EDMONTON

ALBERTA. DEPT. OF THE ENVIRONMENT.
LAND DEVELOPMENT BRANCH.

IRRIGATION STUDIES 1971.

ANNUAL REPORT.

Digitized by the Internet Archive
in 2025 with funding from
Legislative Assembly of Alberta - Alberta Legislature Library

LEGISLATURE LIBRARY
OCT 29 1974
EDMONTON

IRRIGATION STUDIES 1971

ANNUAL REPORT

LAND DEVELOPMENT BRANCH

ALBERTA LAND DEVELOPMENT

R. T. Heywood
Agrologist,
R. D. Neilson
Summer Assistant,
D. Eriksen
Technical Assistant

FEBRUARY, 1972

TABLE OF CONTENTS

1. Summary of Studies 1
   A. Oliver Irrigation Project 1
   B. Morinville Project 1
   C. Edson Project 1
   D. Peace River Corn Project 2
   E. Falher Alfalfa Irrigation Project 2

2. Oliver Irrigation Project 3
   A. Introduction 3
   B. Methods 3
      (a) Study Site 3
      (b) Cultural Practices 3
      (c) Irrigation Procedures 5
      (d) Soil Moisture and Moisture Use 5
   C. Results 6
      (a) Yield and Quality of Alfalfa Hay 6
      (b) Moisture Consumption 7
   D. Discussion 9
      (a) Soil Moisture Tension 9
      (b) Soil Moisture Quantitative Measurement 12
      (c) Irrigation Scheduling Using Risk Analysis 20

3. Morinville Project 22
   A. Introduction 22
   B. Methods 22
      (a) Relocation of Study Site 22
      (b) Soil Quality 22
      (c) Soil and Water Sampling 22
      (d) Crop Management 24
      (e) Irrigation 24
   C. Results 25
      (a) Crop yield 25
      (b) Moisture Consumption 25
   D. Discussion 25
      (a) Crop Yield 25
      (b) Moisture Use 26

4. Edson Project 28
   A. Introduction 28
   B. Methods 28
      (a) Plot Site 28
      (b) Activties in 1971 28
   C. Results 28
   D. Discussion 30

5. Peace River Corn Project 32
   A. Introduction 32
   B. Methods 32
      (a) Location of the Study 32
      (b) Water Supply and Irrigation 32
      (c) Crop Practices 34
      (d) Analysis of Results of Irrigation 34
      (e) Moisture Measurements 34
      (f) Frost Control 35

C. Results 35
(a) Corn Production 35
(b) Moisture Consumption 37
D. Discussion 37
(a) Corn Production 37
(b) Moisture Levels and Use 38
(c) Frost Control 41

6. Falher Alfalfa Irrigation Project 42
A. Introduction 42
B, Method and Description..... 42
(a) Study Site 42
(b) Soil Characteristics 42
(c) Water Supply and Irrigation Practices 44
(d) Crop Management Practices 44
(e) Soil Moisture Measurements 45
C. Results 45
(a) Alfalfa Production 45
(b) Moisture Requirements 46
(c) Soil Moisture Infiltration 47
D. Discussion 47
(a) Alfalfa Production..... 47
(b) Soil Moisture Levels and Use 48
(c) Moisture Infiltration 52

7. Conclusion 53

8. Future Needs 55

9. Literature Cited 56

ILLUSTRATIONS

Figure I	Oliver Irrigation Site	4
Figure II	Soil Moisture Tension, Irrigation and Precipitation Irrigated Site	10
Figure III a	Soil Moisture Level Irrigated Alfalfa Plot...	13
Figure III b	Soil Moisture Level Non-Irrigated Alfalfa Plot	14
Figure IV	Morinville Project Site	23
Figure V	Edson Project Site	29
Figure VI	Peace River Corn Project Site	33
Figure VII	Soil Mosture Tension, Irrigation and Precipitation at Irrigated Site	39
Figure VIII	Falher Alfalfa Irrigation Project Site	43
Figure IX a	Soil Moisture Tension, Irrigation and Precipitation Irrigated Site	49
Figure IX b	Soil Moisture Tension, Precipitation Non-Irrigated Site	50

TABLES

Table	I	Yield of Alfalfa Hay 1971 Oliver Tree Nursery Plots	6
Table	II	Laboratory Analysis of Alfalfa Hay for Quality Expressed as Percent	8
Table	III a	Soil Moisture Consumption By Irrigated Alfalfa In Inches	7
Table	III b	Soil Moisture Consumption By Non- Irrigated Alfalfa In Inches	9
Table	IV	Soil Moisture and Moisture Tension at Time Of Irrigation	11
Table	V	Consumptive Use of Alfalfa and Estimated Evapotraspiration	16
Table	VI	Moisture Consumption by Alfalfa 1971	18
Table	VII	Average Daily Consumptive Use 1971	19
Table	VIII	Brome-Alfalfa Hay Yield in Ton/Acre	25
Table	IX	Moisture Use In Inches of Water	25
Table	X	Moisture Use In Inches by Irrigate Brome-Alfalfa Hay 1971	27
Table	XI	Precipitation and Estimated Plant Use In Inches at Edson - 1971	31
Table	XII	Analysis of Variance Design Factorial 2 x 2	35
Table	XIII a	Average Cob Length Sweet Corn Peace River, Alberta	36
Table	XIII b	Plant Harvest Dates and Time to Maturity of Two Varieties of Sweet Corn 1971	36
Table	XIV	Yield of Sweet Corn in Dozens of Ears/Acre	37
Table	XV	Plant Population of Sweet Corn 1971	38
Table	XVI	Moisture Use and Rate of Use by Sweet Corn 1971	40
Table	XVII	Average Soil Quality and Moisture Holding Capacities	44

.....2

TABLES CONTINUED .....

Table	XVIII	Yield of Alfalfa Hay 1971	45
Table	XIX	Laboratory Analysis of Alfalfa Hay For Quality Expressed As Percent.....	46
Table	XX	Moisture Use by Alfalfa 1971	47
Table	XXI	Comparison of Precipitation for 1971 and the 1931 - 1960 Fairview Average.....	48
Table	XXII	Rate of Moisture Use by Alafalfa 1971.....	51

IRRIGATION STUDIES 1971

1. SUMMARY OF STUDIES

The objective of the irrigation studies being carried out in the Central Alberta and Peace River Regions is to evaluate the potential and indicate the limitations of irrigation in these areas. Positive results are indicated to potential users through the farm irrigation advisory service, available April 1, 1972, from the Irrigation Division of the Alberta Department of Agriculture (formerly the Land Development Branch, Water Resources Division, Department of The Environment). Each study was carried on independently since adequate control was difficult to maintain over growing conditions.

A. Oliver Irrigation Project

In this project control is maintained over as many factors as possible within the limits set by the climate of the Edmonton area. Alfalfa production and its quality are tested under both an optimum moisture level and normal dry conditions. In 1971, irrigation increased alfalfa yield by 1 ton/acre and had a variable effect on quality. Moisture use by the irrigated crop was estimated at 22 inches and by the non-irrigated crop at 16 inches.

B. Morinville Project

Irrigation with sewage effluent had little effect on yield of alfalfa brome hay. The alfalfa irrigated the previous year was broken up during early June, necessitating the choice of another study site. Irrigation was not started until mid June after the start of the rains which alleviated the spring drought. The heavy hail encountered in the Morinville area in 1971 precluded any second hay cut.

C. Edson Project

Irrigation was not required in this project in 1971, but the effect of

irrigation in 1970 still appeared evident. The area irrigated the previous year had a heavier hay crop with a more uniform mix of alsike and timothy. The irrigated hay matured earlier and hence was cut earlier and under the conditions experienced this season, either a second cut of hay or good pasture was possible.

D. Peace River Corn Project

Several types of market vegetables are grown along the Peace River. Most of the growers use some form of irrigation in their garden operation. In the past season the effect of good irrigation practices on sweet corn was studied. Good irrigation increased cob length slightly and appeared to reduce the time required to produce a marketable ear of corn.

E. Falher Alfalfa Irrigation Project

Irrigation was carried out on dry land alfalfa. Yield increases of 0.5 ton/acre were obtained with some improvement in alfalfa quality. Further yield increase would have been expected if proper irrigation had been possible in May.

2. OLIVER IRRIGATION PROJECT

A. Introduction

The Oliver irrigation study attempts to evaluate the potential of irrigation of alfalfa hay in Central Alberta. The project has now extended over 3 years and is beginning to provide an estimation of annual irrigation demands, times of this demand, and the type of yield which can be obtained.

B. Methods

(a) Study Site

The study is being conducted on the Alberta Tree Nursery at Oliver just east of Edmonton. Total area is approximately two acres but sewage line construction in the fall of 1970 has reduced the size of the study area slightly. The study area has been subdivided into irrigated and non-irrigation sections (Figure 1).

(b) Cultural Practices

The entire study area was seeded in June 1969 to alfalfa, without the use of a cover crop. Irrigation was used to establish a uniform stand of alfalfa.

In 1970 and 1971, both irrigated and check portions of the plot received similar treatment except for irrigation. In 1971, 100 pounds of 11-48-0 fertilizer was applied in the spring and after harvesting the first crop. Arrangements were made with a local farmer to cut and bale the hay so that the results obtained from the study could reflect actual farm practices.

From each crop and treatment ten forage samples were taken for quality analysis. Each sample consisted of eight cores of forage, with two cores taken from each of four bales chosen at random. On each sample, the Provincial Soils and Feeds Testing Laboratory carried out analyses for percentage fiber, protein, phosphorous, calcium, nitrate, organic matter

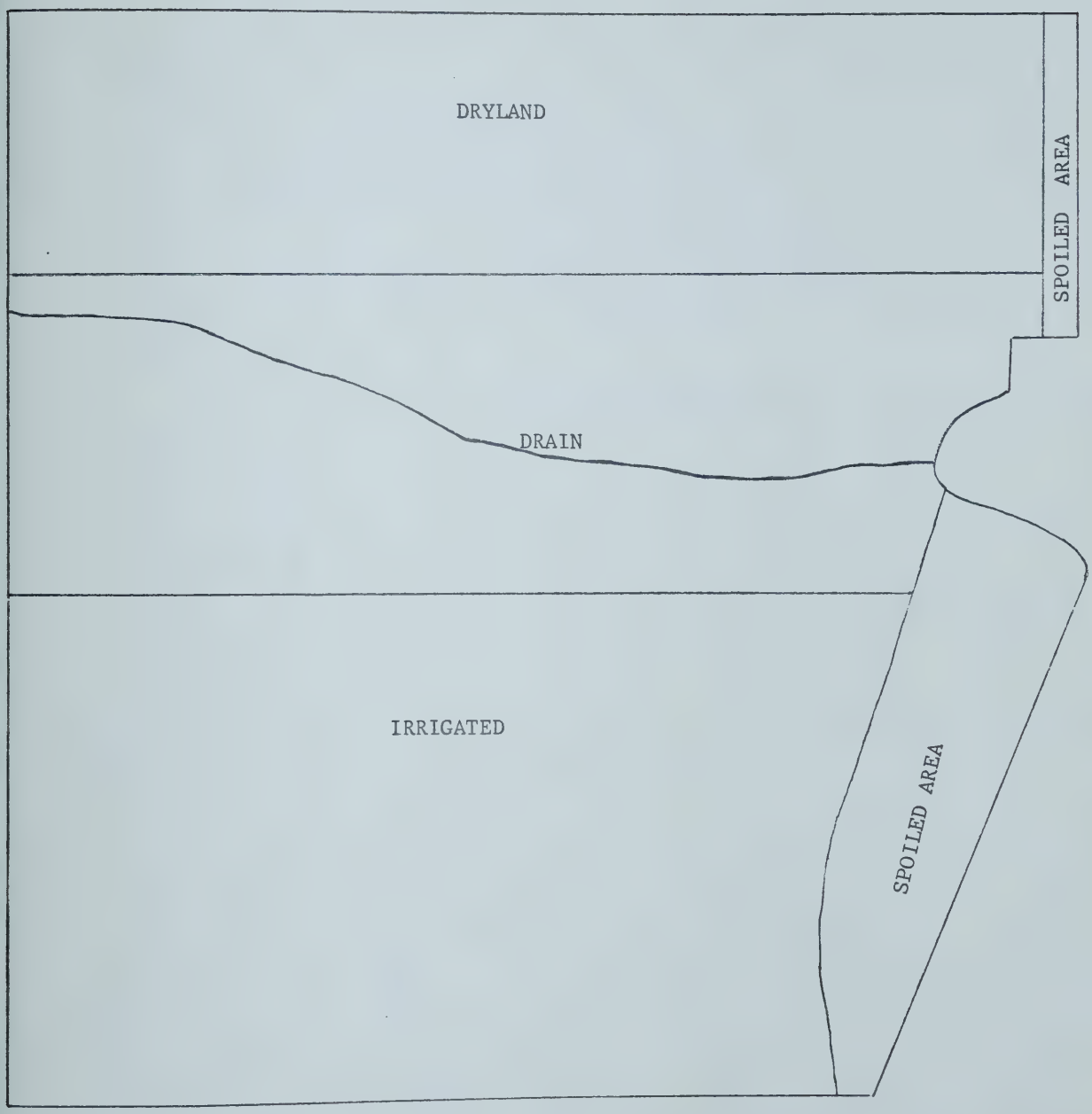

FIGURE I: OLIVER IRRIGATION SITE

digestibility, and percentage of leaves.

(c) Irrigation Procedures

The irrigation system employed a 40' x 40' (nozzle spacing x move) design. The system provided an application rate of 0.40 inches per hour (in/hr) when each sprinkler operated at 60 pounds per square inch (psi). During the second irrigation, high soil moisture at the soil surface decreased the infiltration rate to the level where the 0.40 in./hr application rate was too high. The irrigation system was then operated at 45 psi to provide an application rate .34 in.hr.

Irrigation was scheduled by observing the results of soil moisture tensiometers and gravimetric soil moisture sampling, and using the probability of future rainfall indicated by Risk Analysis of Weekly Climatic Data for Agricultural and Irrigation Planning (2). If the probability of one inch of rainfall in the next week was 0.2 or greater, irrigation was not commenced until the available moisture dropped to below 40%. The results obtained by these methods were also compared to the values calculated from the Gen Atmometer data (Hydrology Branch, Water Resources Division) (4).

(d) Soil Moisture and Moisture Use

Soil moisture measurements were made by:

1. gravimetric sampling
2. tensiometers
3. nylon soil moisture blocks
4. neutron probe.

The gravimetric soil moisture samples were taken weekly from the depths 0 - .5, .5 - 1.5, 1.5 - 2.5, 2.5 - 3.5, 3.5 - 4 feet by a king tube. These values were used for calibrating the soil moisture blocks. The soil moisture blocks were installed at the depths of one, two, three and four feet. The tensiometers installed at the depths of one, two, and three were considered

to provide a qualitative measure of soil moisture. Neutron probe access tubes were installed by the Hydrology Branch and readings were taken at one, two, three, and four feet occasionally over the summer.

The results from the Agrohydrology's Gen Atmometer and rain gauge installation at the Oliver Tree Nursery were obtained to provide a record of rainfall and an estimation of evapotranspiration.

C. Results

(a) Yield and Quality of Alfalfa Hay

Both yield and quality of the alfalfa hay resulted from a combination of growing conditions, stage of harvest, and weather conditions during harvest.

During May and June, the irrigated treatment grew steadily but the non-irrigated treatment did not. Early in June flowering began in the non-irrigated treatment but stopped after the June rains. Flowering of the irrigated alfalfa started at the end of June. The non-irrigated alfalfa flowered again in early July, Harvest was delayed by adverse weather until July 14. Regrowth was most rapid under the irrigation treatment. The non-irrigated alfalfa began flowering the 20th of August while the irrigated alfalfa did not flower until the end of August. Both crops were harvested on September 7, 1971.

The yield obtained from each crop is indicated in Table I.

TABLE I YIELD OF ALFALFA HAY 1971
OLIVER TREE NURSERY PLOTS

	Irrigated ton/acre	Non-irrigated ton/acre
1st Cut	2.58	1.76
2nd Cut	1.82	1.62
Total Yield	4.40	3.38

During the past two years a substantial change in plant population from treatment has been visibly noted. The plant population of the irrigated

alfalfa decreased to a much greater extent than the non-irrigated treatment. This is likely related to fall growth pattern of the two treatments.

The results of anlysis carried out by the Soil and Feed Testing Laboratory are given in Table II for percentage of leaves, protein, fiber, calcium, phosphorus, nitrate, and organic matter digestibility (O.M.D.)

Irrigation in 1971 produced a significant increase in protein and phosphorus. However, irrigation produced a significant increase in percentage of leave, fiber and calcium in one crop but a decrease in the other crop. The percentage of nitrate and O.M.D. are non significant. The nitrate level in all cases indicates a potential danger in the feeds use. The cause of the nitrate level will be investigated.

(b) Moisture Comsumption

The moisture consumed as calculated from rainfall, irrigation, and changes in soil moisture as measured by gravimetric soil moisture sampling, soil moisture block and neutron probe*, are reported in Tables III a and III b.

TABLE III a SOIL MOISTURE (IN INCHES) CONSUMED BY IRRIGATED ALFALFA

Means of Measurement	Period of Measurement		
	April 25-Sept. 27	May 10-Sept. 27	May 25- Aug. 31
Gravimetric Soil Moisture	21.64	20. 38	16.71
Soil Moisture Blocks		21.26	15.34
Neutron Probe			17.31

* Agrohydrology Section, Hydrology Branch, Water Resources Division, Alberta Department of The Environment.

TABLE II

LABORATORY ANALYSIS OF ALFALFA HAY

FOR QUALITY-EXPRESSED AS PERCENT

FACTOR	1st CUT			2nd CUT		
	Irrigated	Non-Irrigated	Significance	Irrigated	Non-Irrigated	Significance
% leaves[1]	36.84	33.31	* *	35.00	41.00	* *
% protein[2]	16.69	15.83	*	18.30	17.20	* *
% fiber[2]	39.03	40.51	* *	40.70	35.40	* *
% calcium[2]	1.47	1.31	* *	1.39	1.39	* *
% phosphorus[2]	0.29	0.24	* *	0.30	0.21	* *
% nitrate[2]	0.84	0.81	N.S.	0.91	0.72	N.S.
% O.M.D.[1]	60.80	58.30	N.S.	63.00	64.30	N.S.

* * significance at 1% level

* significance at 5% level

[1] percent wet weight

[2] percent dry weight

TABLE III b SOIL MOISTURE (IN INCHES) CONSUMED BY IRRIGATED ALFALFA

Means of Measurement	Period of Measurement		
	April 25-Sept. 27	May 10-Sept 27	May 25-Aug. 31
Gravimetric Soil Moisture	14.66	11.85	7.40
Soil Moisture Blocks		16.55	8.80
Neutron Probe			7.74

The moisture use as determined by the several methods shows some variation, as expected. It appears that irrigated alfalfa was able to consume 21 to 22 inches of moisture while the consumption from non-irrigated alfalfa was limited to 15 to 16 inches by lack of available moisture.

D. Discussions

(a) Soil Moisture Tension

The soil moisture tensions at one, two, and three feet as measured by soil tensiometers are given in Figure II. Rainfall and irrigation are also indicated. Tensiometers were not installed on the irrigated plot because soil moisture levels not effectively recorded by the tensiometers were expected during most of the growing season.

During mid July, the tensiometer at the depth of two feet failed to respond to rainfall or irrigation as the tensiometers at one and three feet did. Table IV indicates soil moisture tension (one, two, and three feet), gravimetric soil moisture (four foot zone) and moisture block moisture (four foot root zone), when each irrigation was applied.

Tensiometers are generally considered to indicate the removal of one-half of the available water when the tension reaches 50 centibars. In each case when the moisture tension at the depth of one foot reached 50 to 60

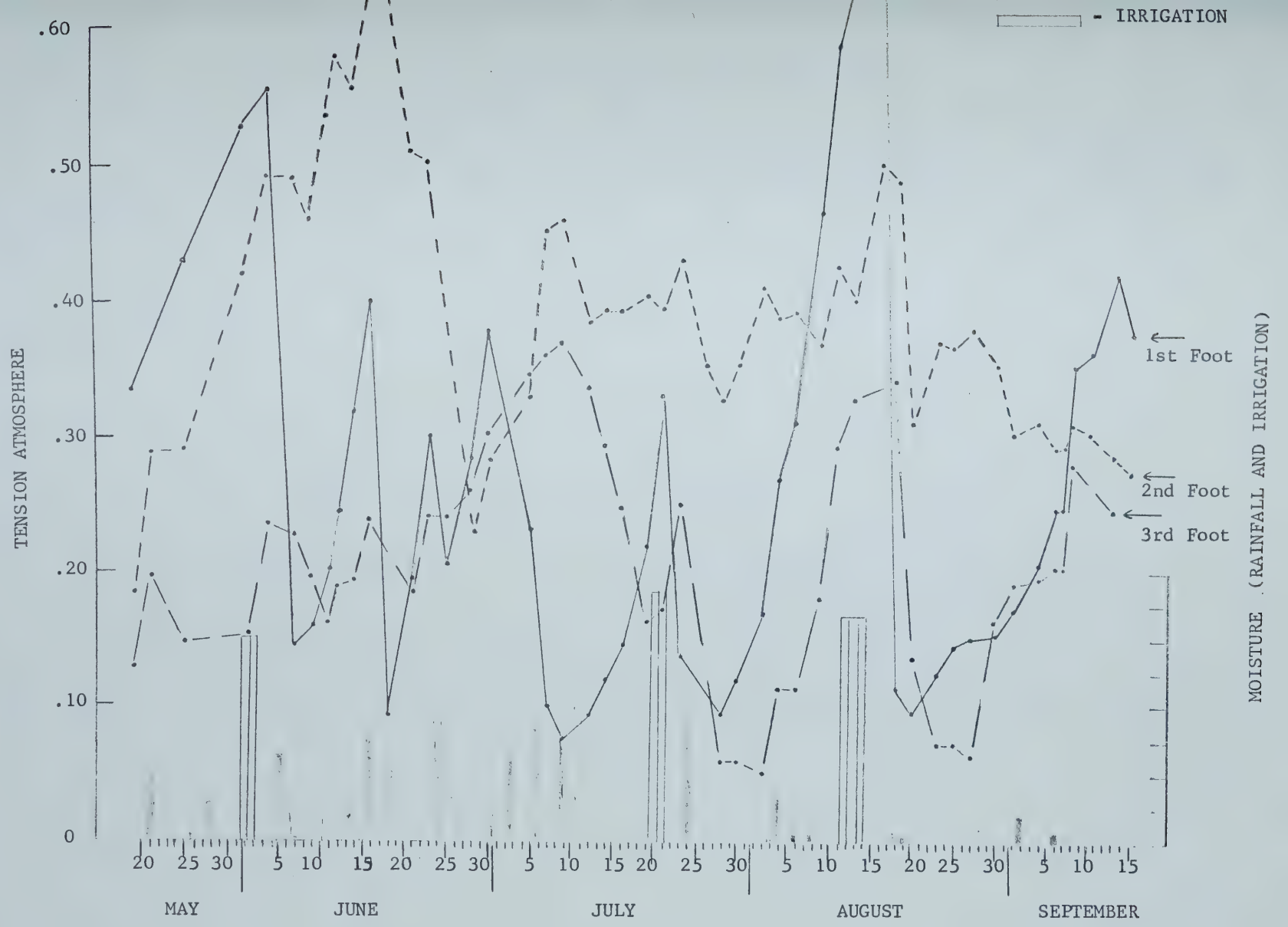

FIGURE II: SOIL MOISTURE TENSION, IRRIGATION AND PRECIPITATION, IRRIGATED SITE

TABLE IV SOIL MOISTURE AND MOISTURE TENSION AT TIME OF IRRIGATION

	Soil Moisture Tension (centibars)				
	1 ft.	2 ft.	3 ft.	Gravimetric Moisture inches of water	Moisture Block inches of water
1st Irrigation (June 7)	60	50	25	3.13	4.00
2nd Irrigation (July 21)	33	44	17	6.40	5.10
3rd Irrigation (Aug. 16)	66	43	34	5.60	4.50

PERCENT AVAILABLE MOISTURE AS MEASURED BY

Gravimetric Method	Moisture Blocks
34.0	43.4
70.0	55.2
60.6	48.7

centibars, irrigation was started. At this time soil moisture, indicated by soil sampling and moisture block reading, varied from 34% to 60% of the total available moisture. This variation is likely the result of using a single tensiometer reading to represent the net result of a number of rainfall and irrigation events. The second irrigation was carried out after the first harvest simply to raise the available moisture in the soil to a high level with the hope that this would be the only irrigation required.

(b) Soil Moisture Quantitative Measurement

Figures III a and b provide a record of the soil moisture as measured gravimetrically, by moisture blocks, and by neutron probe* for both irrigated and non-irrigated study areas.

The moisture determinations obtained from gravimetric and moisture block data are comparable except for the early part of the season under non-irrigated conditions. The similarity is expected since the gravimetric soil moisture determinations were used in calibrating the soil moisture blocks. The major discrepency noted in the early part of the spring at the non-irrigated site reflects the poor fit between soil moisture block readings and gravimetric moisture determinations. No explanation for this discrepency is available. The limited neutron probe data provides a somewhat similar pattern of moisture use but appears to indicate a lower level of available moisture in all cases. This would indicate earlier irrigation dates than those indicated by any of the other methods of measuring moisture use.

The dry land crop reduced the soil moisture level below the calculated wilting point after early August. The crop continued to survive and actually grew after this point, indicating that additional moisture was obtained from depths of soil beyond the depth considered by the calculations.

*Hydrology Branch - Agrohydrology Section

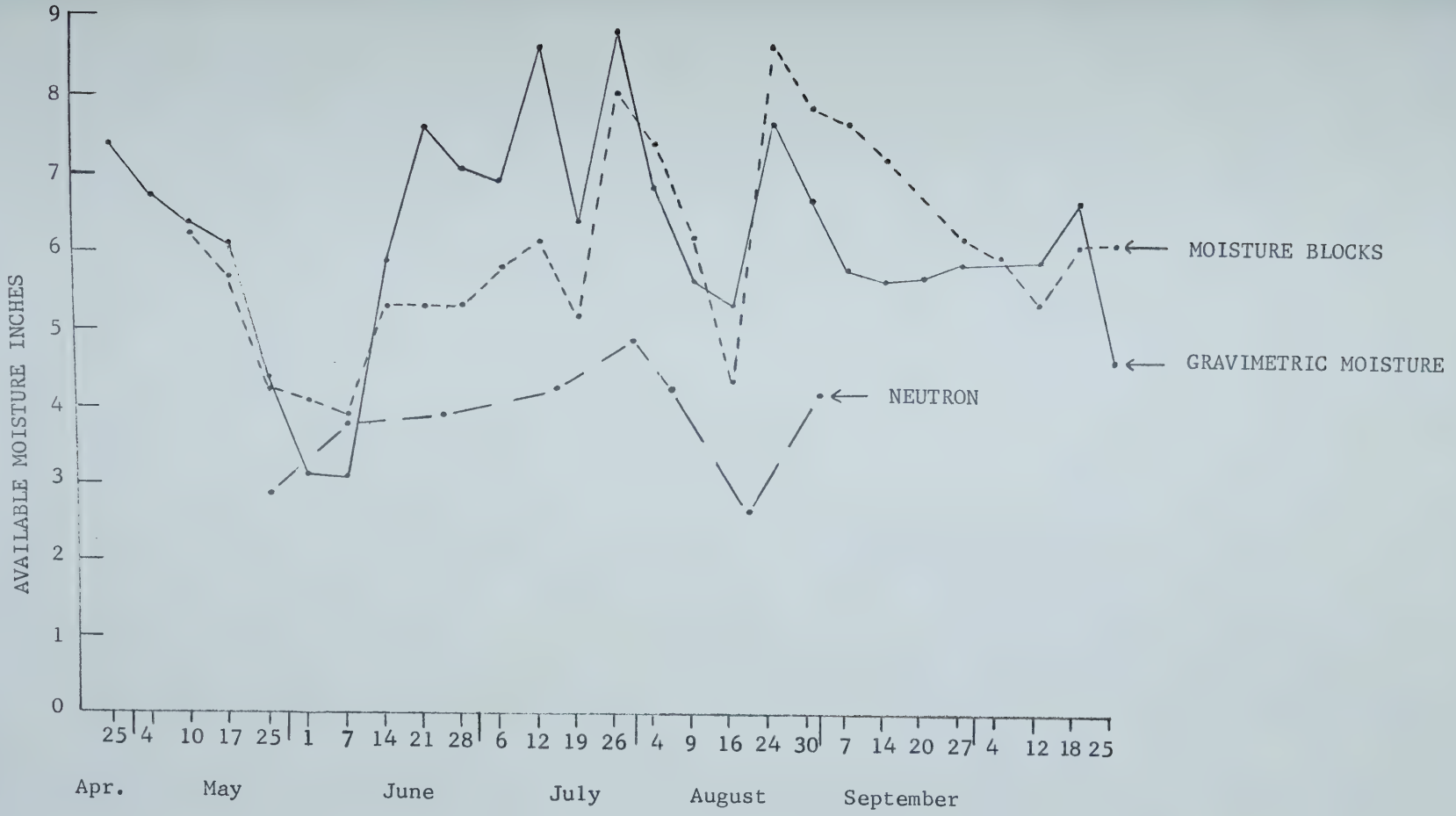

FIGURE III a: MOISTURE LEVEL IRRIGATED SITE

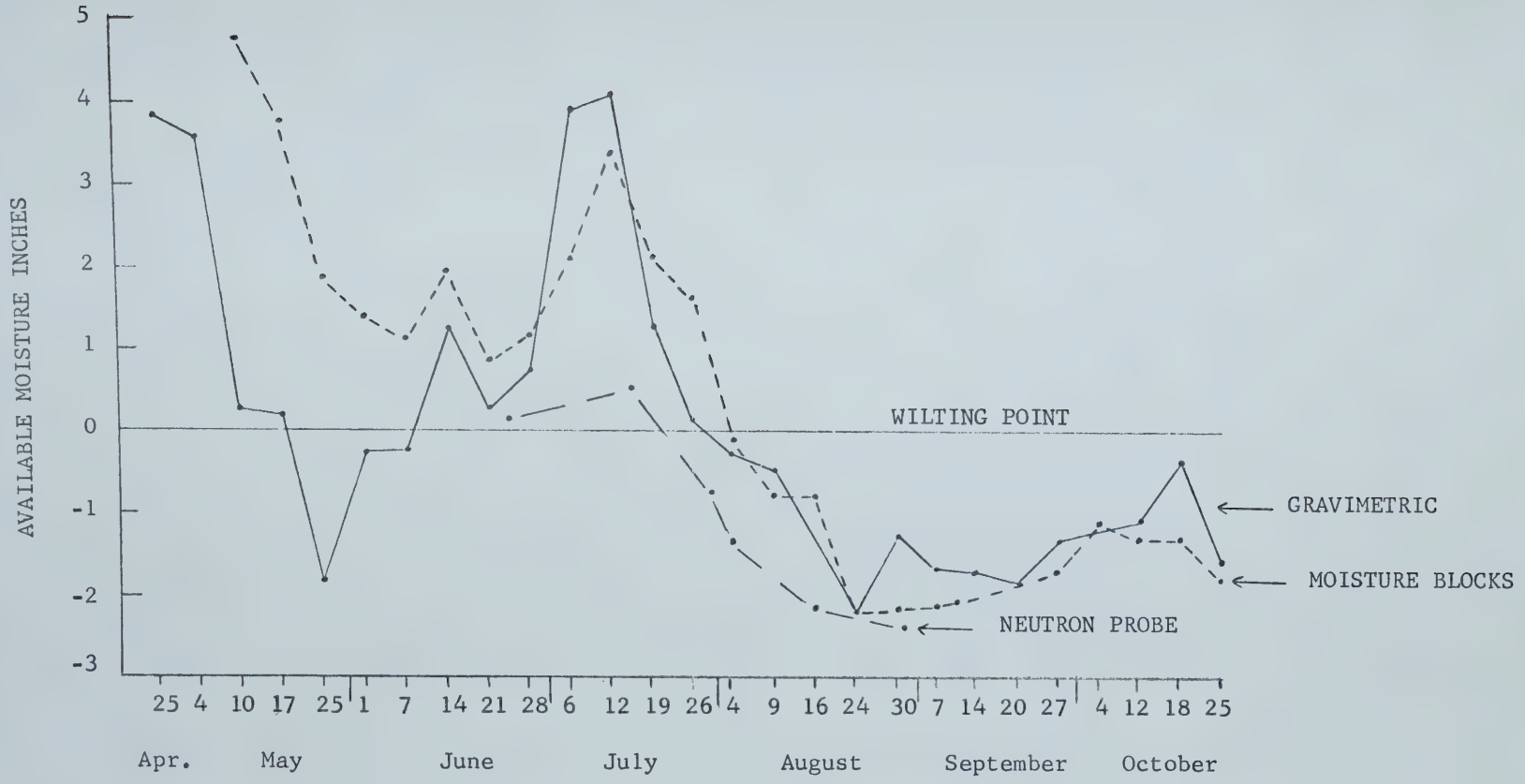

FIGURE III b: SOIL MOISTURE LEVEL NON-IRRIGATED ALFALFA PLOT

The amount of moisture consumed during any period is equal to the amount of moisture entering the system and the change in the moisture within they system minus other losses (surface runoff, deep percolation).

In making these calculations, the following assumptions are made:

1. no surface runoff
2. no deep percolation
3. no soil moisture used from outside the designated root zone.

All these assumptions are invalid to some degree but not to an extent to produce major error. Surface runoff will occur only when high rates of rainfall or heavy rainfall occur. Deep percolation will only occur when the soil reaches field capacity to a depth of the root zone. This may happen occasionally on the irrigated part of this test plot. On the dry land area it is almost a certainty that the alfalfa roots can penetrate to below the four foot depth in search of moisture. There is some indication that upward moisture movement into the root zone also occurs in the non-irrigated area.

Table V indicates the moisture use as determined from gravimetric moisture determinations, soil moisture block measurements under both irrigated and non-irrigated conditions as well as evapotranspiration as calculated from the Gen Atmometer evaporation using 1970 coversion coefficients.*

The weekly moisture use as measured by the various methods indicates a wide degree of variation. The negative values in most cases will represent accumulative sampling errors, lag time in the moisture blocks and the problem of an erreonous June 7 gravimetric soil sampling. It has been estimated that soil moisture sampling by gravimetric means will have at least $\pm$ 10% error.

The consumptive use as estimated by the Gen Atmometer reflects the climate conditions during the period of measurement. High use from mid May to early June occured during a dry sunny period. From early June until mid

* Hydrology Branch - Agrohydrology Section

TABLE V

CONSUMPTIVE USE OF ALFALFA AND
ESTIMATED EVAPOTRANSPIRATION 1971

PERIOD	EVAPOTRANSPIRATION BY ALFALFA-INCHES OF WATER	CONSUMPTIVE USE - INCHES OF WATER			
		IRRIGATED AREA		NON-IRRIGATED AREA	
	GEN ATMOMETER DETERMINATION	GRAVIMETRIC DETERMINATION	MOISTURE BLOCKS DETERMINATION	GRAVIMETRIC DETERMINATION	MOISTURE BLOCKS DETERMINATION
April 25-May 4		0.95		0.13	
May 4 - " 10		0.31		2.68	
May 10 - " 17		0.49	0.72	0.27	0.69
May 17 - " 25	1.36	1.98	1.74	2.54	2.30
May 25 -June1	1.40	1.64	0.67	-1.33	0.71
June 1 - " 7	0.84	0.74*	0.87	0.74*	1.04
June 7 - " 14	0.49	-0.17*	1.23	-1.15*	-0.41
June 14 - " 21	0.35	0.01	1.58	2.48	2.82
June 21 - " 28	0.77	1.50	1.00	0.75	0.75
June 28-July 6	0.96	0.99	0.48	-2.31	-0.08
July 6 - " 12	0.54	0.71	2.17	2.26	1.06
July 12 - " 19	1.75	2.32	0.96	2.92	1.37
July 19 - " 26	0.98	1.50	1.03	2.06	1.48
July 26-Aug. 4	2.27	2.12	0.79	0.34	1.68
Aug. 4 - " 9	1.07	1.49	1.50	0.63	1.01
Aug. 9 - " 16	1.63	0.54	1.80	0.62	0.05
Aug. 16 - " 24	2.13	2.24	0.42	1.30	1.56
Aug. 24 - " 30	0.97	1.08	0.84	-1.17	-0.04
Aug. 30-Sept.7	1.80	1.00	0.41	0.74	0.16
Sept. 7 - " 14		0.16		0.12	
Sept.14 - " 20		0.06	1.79	0.15	0.41
Sept.20 - " 27		-0.02		0.09	

* The gravimetric moisture used for the June 7 determination is an assumed value equal to the June 1 gravimetric moisture content. The June 7 gravimetric value determined for both treatments was irrelevant. It appeared that drying might have been carried out in the high temperature oven since loss of organic matter would have accounted for the deviation from expected values.

July, dry sunny conditions again increased use as indicated by the Gen Atmometer. On the irrigated area, moisture use calculated from soil sampling gives fairly good agreement when it is considered that soil sampling error of 10% is considered acceptable accuracy. The moisture blocks over-estimated moisture use by the first crop and under-estimated it by the second cut and indicated a steadier level of use than either of the other methods. However, over the season total use by each method was approximately the same (Table VI).

Moisture use from the non-irrigated area does not follow the use estimated by the Gen Atmometer because available moisture was insufficient to fill the demand. Moisture use was limited by drought in late May, early June, and much of August. When moisture was available, the moisture used was much the same as from the irrigated area. From the non-irrigated area total use, as measured by the two methods (gravimetric and moisture blocks), was not the same (Table VI). The discrepency results from a greater percentage of available moisture at the moisture block site than the point of initial gravimetric sampling. This discrepency has already been discussed. It is also possible that additional moisture could have been obtained from below the four foot root level, thus increasing the amount of moisture consumed.

Table VI indicates consumptive use as determined by the neutron probe as well.

Variation occurs in the daily rate of moisture use from week to week; however, over the entire season the daily rate is similar, as measured by each method. The daily rate of moisture consumption predicted by calculation from Gen Atmometer evaporation for the entire season falls between the rates measured by the soil moisture blocks and gravimetric soil sampling under irrigated conditions. As expected, the agreement between various methods of measurement improves as the interval over which calculations are made is lengthened. It appears that the Gen Atmometer gave an adequate prediction

TABLE VI MOISTURE CONSUMPTION BY ALFALFA 1971

PERIOD OF TIME		TREATMENT					
		IRRIGATED			NON-IRRIGATED		
	Gen Atmometer in. of water	Gravimetric Measurement in. of water	Moisture Block Measurement in. water	Neutron Probe Measurement in. water	Gravimetric Measurement in. of water	Moisture Block Measurement in. water	Neutron Probe Measurement in. water
June 25 - Aug. 31	13.07	14.00	10.99	12.44*	7.40	8.84	7.74*
May 25 - Aug. 31	17.15	16.71	15.34	17.34*			
May 17 - Sept. 7	19.31	19.69	17.49		11.42	15.46	
May 10 - Sept.27		20.38	20.00		12.05	16.56	
April 25- Sept.27		21.64			14.86		

In Table VII, the average daily consumptive use for each period is calculated.

* Hydrology Branch - Water Resources Division

TABLE VII

AVERAGE DAILY CONSUMPTIVE USE 1971

PERIOD	GEN ATMOMETER inch / day	IRRIGATED ALFALFA		NON-IRRIGATED ALFALFA	
		Gravimetric Measurement inch / day	Moisture Block Measurement inch / day	Gravimetric Measurement inch / day	Moisture Block Measurement inch / day
April 25 - May 4		0.12		0.02	
May 4 - May 10		0.05		0.45	
May 10 - May 17		0.07	0.10	0.04	0.10
May 17 - May 25	0.17	0.25	0.22	0.32	0.29
May 25 - June 1	0.20	0.23	0.10	-0.19	0.10
June 1 - June 7	0.14	0.12	0.14	0.12	0.17
June 7 - June 14	0.07	-0.02	0.18	0.10	0.17
June 14 - June 21	0.05	0.00	0.23	0.10	0.17
June 21 - June 28	0.11	0.21	0.14	0.11	0.11
June 28 - July 6	0.12	0.12	0.06	-0.29	-0.01
July 6 - July 12	0.09	0.12	0.36	0.38	0.18
July 12 - July 19	0.25	0.33	0.14	0.42	0.20
July 19 - July 26	0.14	0.21	0.15	0.34	0.20
July 26 - Aug. 4	0.25	0.24	0.09	0.04	0.19
Aug. 4 - Aug. 9	0.21	0.30	0.30	0.13	0.20
Aug. 9 - Aug. 16	0.23	0.08	0.26	0.09	0.01
Aug. 16 - Aug. 24	0.27	0.28	0.05	0.16	0.20
Aug. 24 - Aug. 30	0.16	0.18	0.14	-0.20	0.00
Aug. 30 -Sept. 7	0.22	0.12	0.05	0.09	0.02
Sept. 7 -Sept. 14		0.02	0.09	0.02	0.02
Sept. 14 -Sept. 20		0.01	0.09	0.02	0.02
Sept. 20 -Sept. 27		0.00	0.09		0.02
Average use inch/day May 17 - Sept. 7	0.144	0.147	0.131	0.09	0.12

of consumptive rate of moisture over the entire season when moisture levels in the soil were maintained. Also, it appears that variation in other methods (moisture blocks and gravimetric sampling) offers no advantage unless a sufficient number of measurements is made to eliminate sampling errors and local variations in moisture distribution produced by sprinkler uniformity, and variations in crop and soils.

The limited data obtained from the neutron probe provided fairly uniform results but since sampling intervals were not the same as for the other methods, comparison is not possible. The level of available moisture reported by the neutron probe was generally lower than that reported by the other methods but this did not appear to decrease the amount of moisture consumed by the crop.

(c) Irrigation Scheduling Using Risk Analysis

Risk Analysis of Weekly Climatic Data for Agricultural and Irrigation Planning was used in conjunction with the other scheduling method for two of the three irrigations made. The July irrigation was carried out after the first cut since it was convenient and desirable to try to avoid irrigating a heavy stand of hay in late August. The August irrigation was later required since the late July and August precipitation was much below normal.

The Risk Analysis was used to indicate the probability of receiving more than a certain amount of precipitation during the following week. In this case, if the probability of receiving 1.0 inch of rainfall in the next week was 0.2, then irrigation was to be delayed unless soil moisture reached a critical level (35% of total available moisture).

During the 1971 growing season, the predictions made by use of Risk Analysis were similar to those made by other methods. Available moisture had dropped to 50% by late May when the probability of receiving 1.0 inch of rain in the next week was about 0.1. Irrigation was started June 7, by which

time available moisture had dropped to 35% of available moisture. Since the probability of adequate rainfall was high by mid June, a light irrigation was applied. Irrigation again appeared necessary in mid August, Since the probability of receiving 1.0 inch of rain during the next week was low, irrigation was started immediately.

In 1971 the Risk Analysis of Weekly Climatic Data for Agricultural and Irrigation Planning, when combined with adequate knowledge of soil moisture levels, provided an efficient method to estimate both the scheduling and size of irrigation required by alfalfa.

3. MORINVILLE PROJECT

A. Introduction

The objective of this project was to study the feasibility and problems encountered with the disposal of municipal sewage lagoon effluent on agriculture land. It was also hoped to obtain results to indicate the agriculture benefits (increased productivity) possible from using this source of irrigation water. The study was to be carried out by the Land Development and Soils, Geology and Groundwater Branches, with co-operation of both the town of Morinville and a local farmer. Since the farmer involved first summer fallowed the study area and later sold the farm, the study, as it origninated, cannot be completed. However, it was decided to continue to irrigate a site adjacent to the town lagoon.

B. Methods

(a) Relocation of Study Site

The study site was relocated adjacent to the lagoon (Figure IV). To the east of the irrigated test area, a non-irrigated control plot was delineated. The previous (1970) site is also indicated.

(b) Soil Quality

The soil under the new test area was somewhat superior to the area previously used. Visual inspection indicated a lower salt content and less soil structure limitations and it is expected that this soil can be considered normal for irrigation purposes.

(c) Soil and Water Sampling

Soil samples were taken from the new irrigation test plot on June 18 for quality analysis to indicate irrigability. Moisture holding capacities were also to be determined.

Soil samples for determination of moisture content were taken from

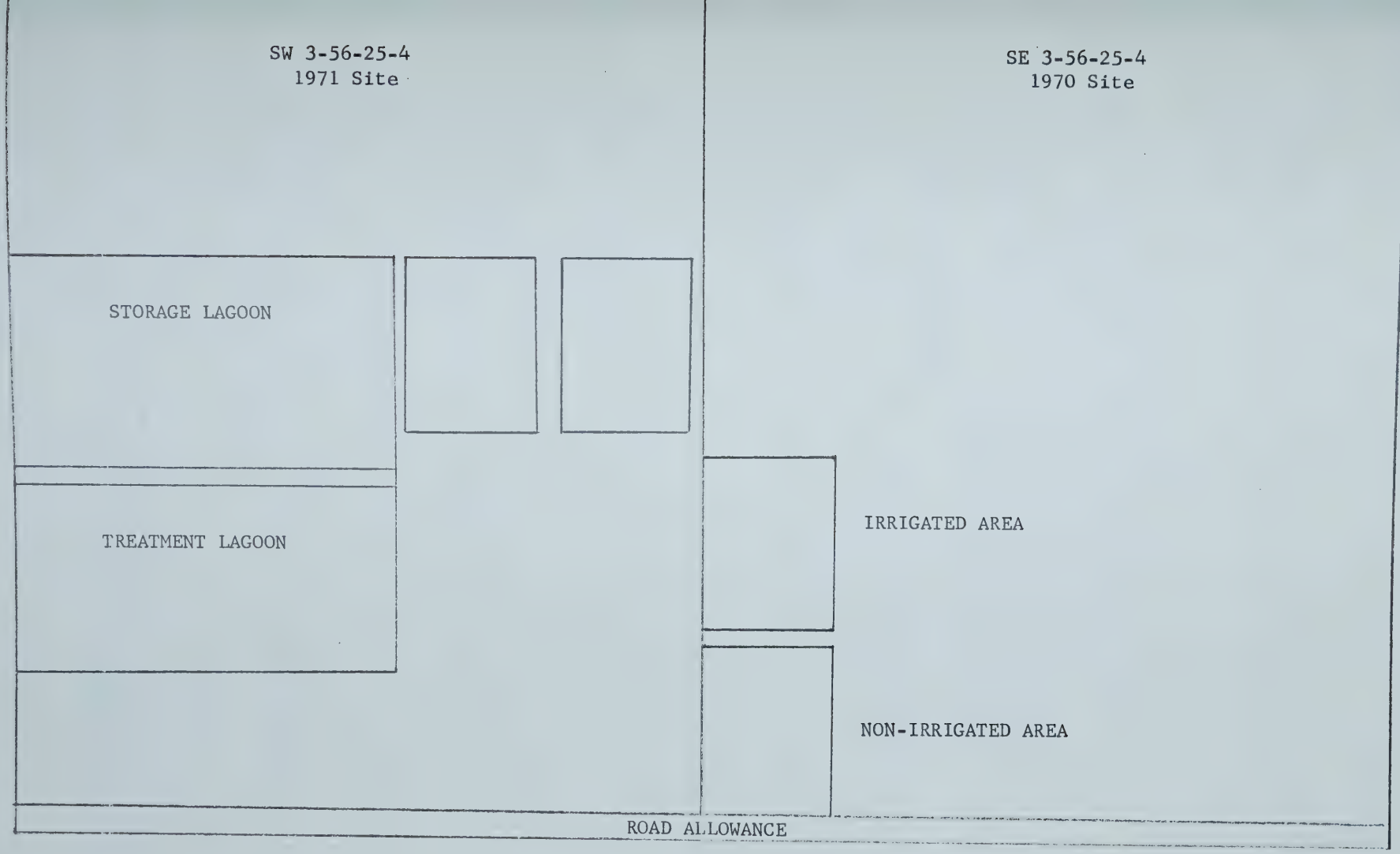

FIGURE IV: MORINVILLE PROJECT SITE

the previous year's irrigated and non-irrigated test sites between May 4 and June 29. Soil moisture sampling began at the new sites on June 18 and continued until the end of September.

On June 21, water samples were taken from the Morinville lagoon for the determination of its quality as irrigation water.

The groundwater wells water levels were not recorded because one collapsed during the spring flood from soil pressure and the others were destroyed by cultivation when the farmer summer fallowed the area.

(d) Crop Management

The previous year's test site was summer fallowed beginning in June. This ended any possible study of this site in 1971. Since reseeding to alfalfa was not indicated, it was decided to relocate the test site adjacent to the town lagoon.

Since almost the entire irrigated study site (1970) had been subjected to a period of flooding before May 4, the soil was virtually at field capacity to the depth of four feet and therefore irrigation was not required during May or early June. This was not true of the new site chosen, since it had not been flooded during April. By the time the site had been chosen and irrigation started, the June rains had eliminated the actual need for irrigation.

The brome alfalfa hay mixture was harvested in late July. Yield measurements were taken by weighing the bales from each area. A severe hail storm in August destroyed the original regrowth of alfalfa, hence no effort was made to obtain a second cutting.

(e) Irrigation

The irrigation test plot was irrigated between June 18 and June 25, 1971. The irrigation system was a 40' x 60'' design, with four sets used to

cover the 400' x 180' test area. The sprinkler nozzle pressure employed was 55 to 60 psi which produced a gross application rate of 0.28 in./hr.

C. Results

(a) Crop Yield

The irrigated area had a slightly lower yield than the non-irrigated (Table VIII).

TABLE VIII ALFALFA BROME HAY YIELD IN TON/ACRE

	Irrigated	Non-irrigated
1st Cut (July 28)	1.40	1.50
2nd Cut	-	-
Total Yield	1.40	1.50

(b) Moisture Consumption

The estimated moisture use by the irrigated and non-irrigated crops is given in Table IX.

TABLE IX MOISTURE USE IN INCHES OF WATER

Irrigated crop (May 4 - Sept. 27	14.13
Non-irrigated crop (May 4 - Sept. 27)	12.42

D. Discussion

(a) Crop Yield

The small difference in yield cannot be considered significant. Irrigation of the new plot had been required earlier than it was provided. During May, virtually no precipitaion occured. In the period from June 4 to 18, 2.50 inches of rain were recorded. During the period when the irrigation was being carried out, an additional 1.50 inches of preciptaion were recorded.

The only function served by the irrigation was to raise the soil moisture level from 35% of total available moisture on the non-irrigated area, to 65% on the irrigated area. In each case moisture remained above these levels until harvest. Neither test area had adequate May moisture conditions, but both received adequate rainfall early in June and one received additional moisture by irrigation. Until harvest, moisture levels remained adequate for good growth on both sites. A small difference in growth was therefore expected.

No yield from a second cut is available because of late cutting and the August hail storm which completely destroyed regrowth. With the lower than normal August rainfall experienced this year, some increase in yield of the second cut of alfalfa would have been expected.

(b) Moisture Use

An attempt to estimate the moisture consumed by the crop has been made using data both from the old and new test sites. The moisture determinations from the old plots were used until June 21 and then the determinations from the new sites were used. The rainfall data from the Agrohydrolgy meteoroligical station at Legal was used to represent precipitation. The showery nature of much of the rainfall meant that differences in precipitation will exist. The most notable difference will be in the precipitation received as hail (August 3). The test plots were in the center of the heaviest hit area, while Legal was not. At least a part of this precipitation ran off. Table X estimates the moisture consumed during each period (approximately a month in length) for both irrigated and non-irrigated crops.

Moisture use during the season was slightly greater in the irrigated area. The difference in August might have resulted from a poorer second recovery of growth on the irrigated area after the hail storn. The May use

TABLE X

MOISTURE USE IN INCHES
BY IRRIGATED BROME-ALFALFA HAY 1971

PERIOD	IRRIGATED CROP	NON-IRRIGATED CROP
May 4 - June 1	1.22	-
June 1 - July 7	5.50	4.54
July 7 - July 26	4.13	3.77
July 26 - Aug. 30	2.70	3.61
Aug. 30 - Sept. 20	0.58	0.50

from both treatments appeared lower than would be expected, considering the weather and soil moisture levels during May 1971.

As mentioned previously, both the new irrigated and non-irrigated test plots had equal moisture conditions until mid June when irrigation was carried out. Moisture in this period was estimated to be 12.9 inches from the irrigated site. This small difference in moisture use would appear to agree with the fact that yields were nearly the same.

4. EDSON PROJECT

A. Introduction

Irrigation is being studied at Edson to provide some information on the limitations of this tool to increase production and to reduce the risk of crop failure. Edson was chosen because a local farmer (Mr. R. Tanghe) was interested in determining whether irrigation could improve the viability of his farm. The other reasons for the site selection were:

(a) availability of water

(b) maximum elevation recommended for agricultural development in this area by Canada Land Inventory[3]

(c) short frost free growing season receiving the minimum number of growing degree-days over 42°F recommended for agricultural development by Canada Land Inventory[3]

(d) greater recorded precipitation than in other areas in Central Alberta.

B. Methods

(a) Plot Site

The plot site adjacent to the Edson River is shown in Figure V. A further description of the site, soil and related information is given in the 1970 report.

(b) Activities in 1971

Mr. Tanghe fertilized the test area with 100 pounds/acre of 21-0-0 fertilizer ($(NH_4)_2SO_4$). At the end of May he indicated that irrigation was required. Before irrigation could be scheduled, adequate precipitation was received to supply the immediate needs of the crop. Irrigation was not deemed necessary at any other time during the growing season.

C. Results

The alsike timothy mixture was considerably altered this year. Last

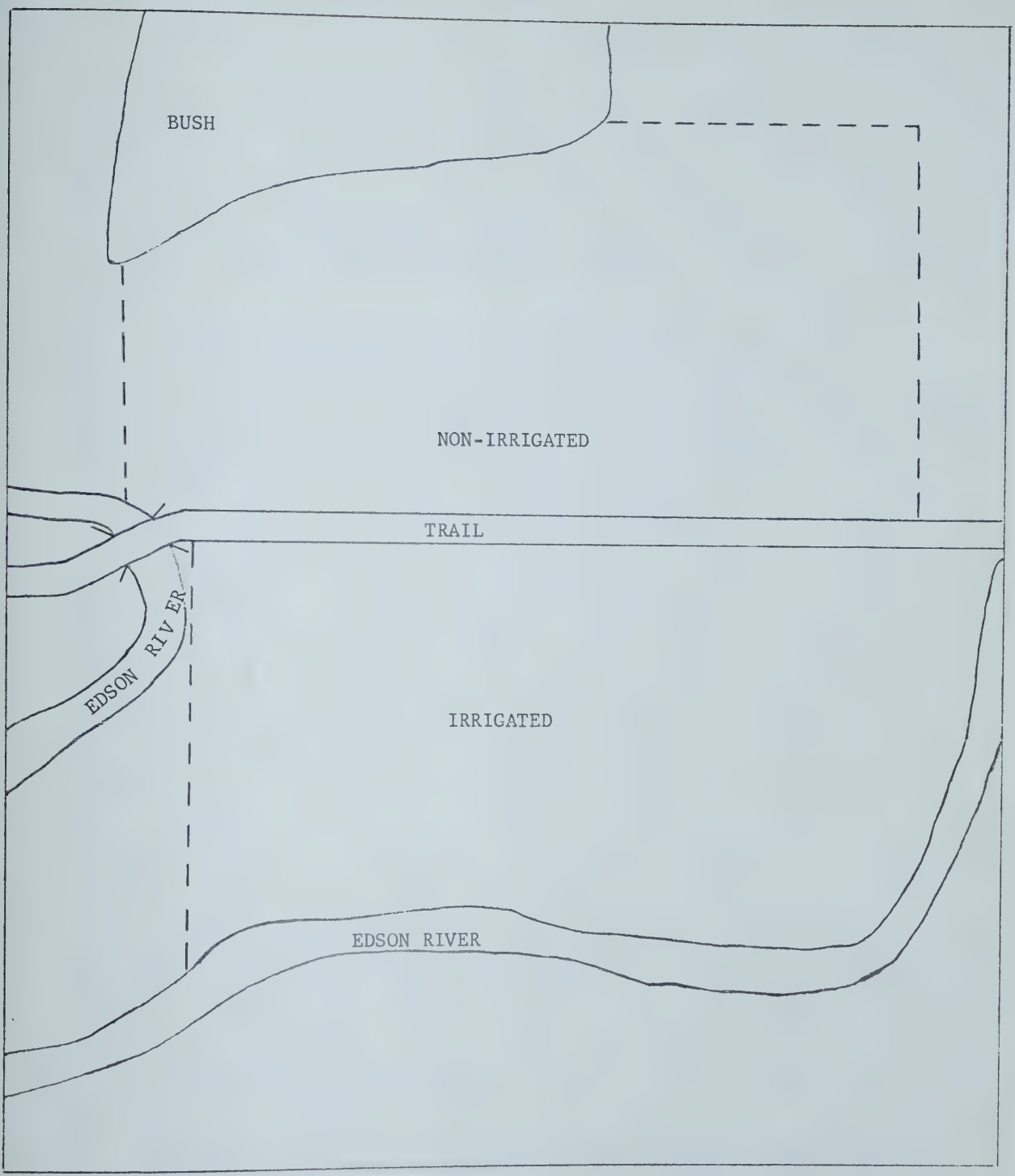

FIGURE V: SITE OF EDSON IRRIGATION STUDY

year timothy growth was uniformly distributed only where irrigation had occurred. This year timothy was more evenly distributed but the irrigated site still had a greater plant population. The alsike population decreased to a great extent in both areas but still represented about 10% of the plant population.

Differences existed in the stage of growth in the two treatment areas. The land irrigated in 1970 produced a suitable maturity for harvest in early July. Yield was estimated by Mr. Tanghe to be 2 ton/acre of cured hay. The non-irrigated area did not produce a crop suitable for harvest until late July when the yield was estimated at approximately 1½ ton/acre. The difference in yield was mainly the result of lower plant density in the areas most prone to drought. The irrigated area also produced a considerable amount of re-growth under the high soil moisture conditions of the 1971 summer. This regrowth would have produced a light hay crop (½ ton/acre estimated) or some pasture.

D. Discussion

The irrigated site (1970) without irrigation in 1971, provided a somewhat better crop than the non-irrigated site. This is likely the result of irrigation promoting a more even germination and development of the forage species. There might also have been some carry-over of soil moisture from the previous year.

Table XI presents the precipitation and estimated plant use at this site in 1971.

Soil moisture at the beginning of May was estimated from the several soil samples to be approximately 5.5 inches (70% of total available moisture.) Assuming a similar rate of moisture use during May as indicated for the late part of the month, it is expceted that moisture would have been reduced to a low level (20% of total available moisture by the end of May. Irrigation

was likely necessary by mid May but its need wat not recognized visually by Mr. Tanghe until the latter part of the month.

TABLE XI PRECIPITATION AND ESTIMATED PLANT USE IN INCHES AT EDSON 1971*

PERIOD	PRECIPITAION	ESTIMATED PLANT USE GEN ATMOMETER
May 17 - 31	0.25	2.57
June 1 - 30	6.50	2.40
July 1 - 31	7.01	4.58
Aug. 1 - 31	2.32	4.91
Sept. 1 - 20	3.01	3.75

* Data from measures made at R. Tanghe's farm by Agrohydrology Section - Hydrology Branch.

5. PEACE RIVER CORN PROJECT

A. Introduction

Along the Peace River southwest of the town of Peace River (Shaftesbury Settlement) there is a considerable market garden industry. Irrigation is used by almost all of the successful market gardeners. In 1970, Land Development started an investigation of market garden irrigation in this region. The purpose was to investigate the potential of "proper" irrigation as it related to these garden crops, and if possible, to promote better irrigation practices in these areas. In 1970, preliminary investigations involving potatoes, tomatoes, cucumbers, and corn were made. In 1971, it was decided to limit study to the one crop involving the greatest acreage, sweet corn. A secondary objective of frost control (prevention) was to be pursued using broad beans as the indicator crop.

B. Methods

(a) Location of the Study

The study is being carried out on the farm of Mr. B. Henderson (River Lot #1, Shaftesbury Settlement). Mr. Henderson provided the seed corn and carried out the necessary cultivation while the Land Development Branch instrumented the study and carried out the necessary irrigation. Figure VI indicates the location of the study area.

(b) Water Supply and Irrigation

The water supply for irrigation is from a dugout filled by a gravity diversion of water from a nearby spring-fed creek.

The irrigation system used a 40' x 60' design with individual nozzles operating at 50 psi. The first two irrigation used 9/64 nozzles to provide a 0.16 in./hr application rate. The third irrigation employed 3/16 inch nozzles at 50 psi to apply 0.29 in./hr.

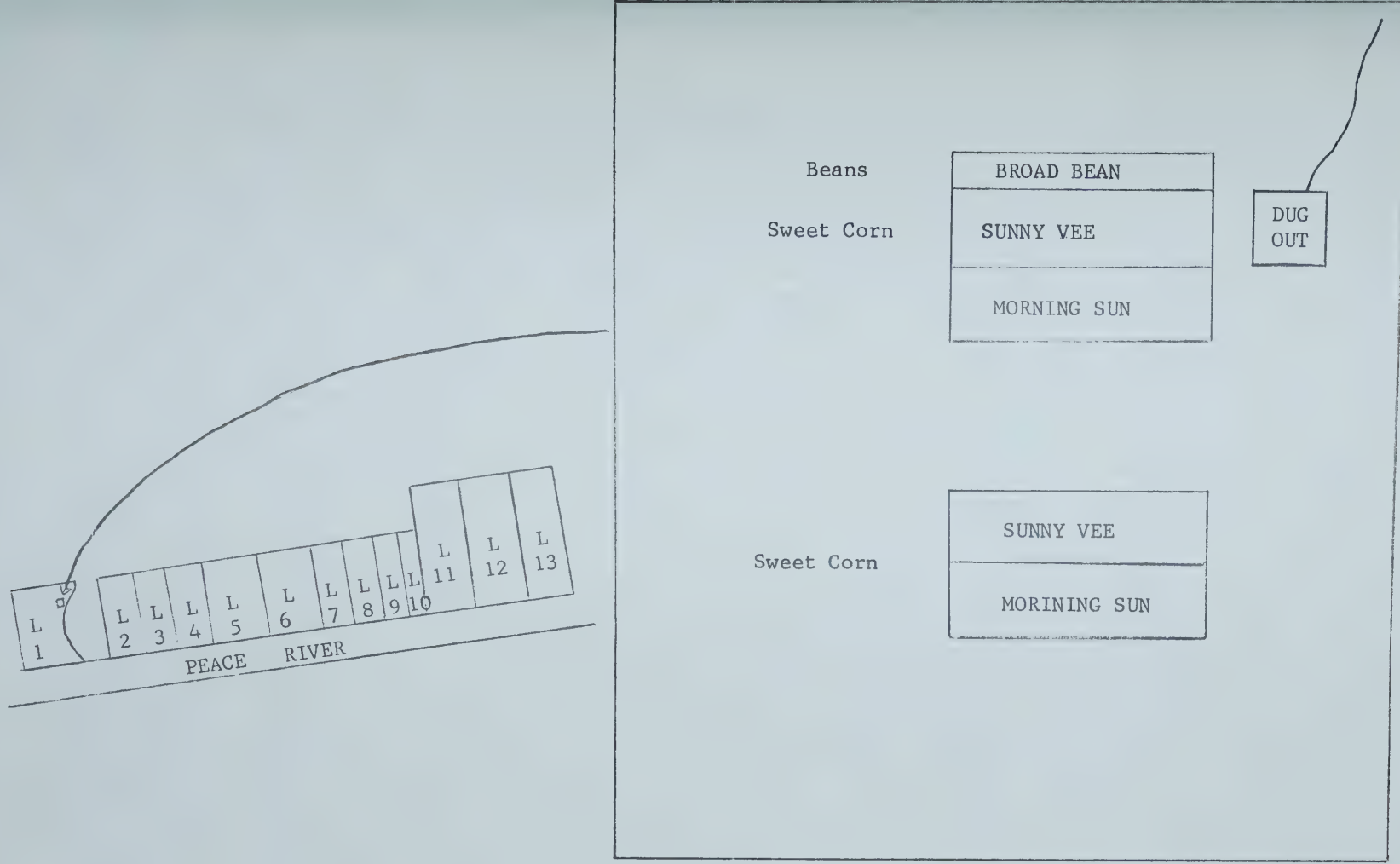

FIGURE VI: PEACE RIVER CORN PROJECT SITE

(c) Crop Practices

On May 24, Mr. Henderson planted in the test area two varieties of corn, Sunny Vee and Morning Sun. The corn row spacing was 40 inches. Seeding and fertilization rates were the same for these varieties, and for the remainder of the corn seeded by Mr. Henderson. All the corn received an irrigation to promote good germination, but the test areas received two additional irrigations.

(d) Analysis of Results of Irrigation

It was decided to compare the Sunny Vee and the Morning Sun varieties in the test area to the same varieties in the remainder of the crop area outside of the test site. This corn was located approximately 400 feet to the south. This part of the crop had been planted on May 16 (eight days earlier than the test site) and received only a single irrigation to promote rapid germination. From each variety and treatment, six sample areas were randomly selected. Each sample area consisted of 5 rows which were 25 feet long (0.0096 acre). In no case did the samples include the ends of rows or the outside four rows of the plots. Within each sample area the following measurements were made:

1. number of plants
2. number of marketable corn ears
3. the length of 10 ears.

An analysis of variance using a 2 x 2 factorial design was performed on the collected data. The factorial design is shown in Table XII.

(e) Moisture Measurements

Several moisture measuring methods were employed to check the moisture levels in the irrigated test site. Soil samples for gravimetric moisture determination were taken periodically at two sites in the test area. Soil

TABLE XII ANALYSIS OF VARIANCE DESIGN

FACTORIAL 2 x 2

FACTOR	CORN VARIETRY - A		
	LEVEL	SUNNY VEE - a_1	MORNING SUN - a_1
Irrigation B	germination irrigation b_1	$a_1\ b_1$	$a_2\ b_2$
	3 irrigations b_2	$a_1\ b_2$	$a_2\ b_2$

tensiometers were installed at the depths of one, two, and three feet.

Consumptive use of moisture was indirectly calculated from the Gen Atmometer data* collected at the Peace River Correction Institute.

(f) Frost Control

Late in August the system was arranged in a 60' x 60' design. The sprinkler nozzles were changed to the 9/64 size in order to provide a 0.12 in/hr coverage at 60 psi. Beans were seeded to act as frost indicator plants[5].

C. Results

(a) Corn Production

The additional irrigation supplied on the test plots increased the cob length slightly in each case (Table XII a) and reduced the number of days required to reach a suitable maturity for use (Table XII b). The sweet corn reached a suitable stage of maturity for harvest in mid August. The Sunny Vee variety was first available August 18 and the Morning Sun by August 25.

* Hydrology Branch - Water Resources Division

TABLE XIII a AVERAGE COB LENGTH SWEET CORN
PEACE RIVER ALBERTA 1971

CORN VARIETY	TREATMENT		COB LENGTH RECORDED IN TESTS
	STARTER IRRIGATION	3 IRRIGATIONS	
Sunny Vee	5.1 inches	5.4 inches	-
Morning Sun	5.7 inches	6.1 inches	7 - 8 inches

TABLE XIII b PLANT HARVEST DATES AND TIME TO MATURITY
TWO VARIETIES OF SWEET CORN
1971

VARIETY	SUNNY VEE		MORNING SUN	
TREATMENT	IRRIGATED	GERMINATION IRRIGATION ONLY	IRRIGATED	GERMINATION IRRIGATION ONLY
Planting Date	May 24	May 16	May 24	May 16
Harvest Date	Aug. 18	Aug. 18	Aug. 25	Aug. 25
Days	85	94	96	99
Days to Maturity Smitheld Experimental Farm 1971	83		85	

The ear length obtained in 1971 was less than desired and reported for these varieties in other areas. In the time when ear filling was occurring a period of drought was encountered. Moisture was more readily available on

the test site than on the other site so growth was more rapid and slightly more productive. Total yield in dozens of ears of sweet corn has been estimated from the average number of cobs found in the measured areas (Table XIV).

TABLE XIV YIELD OF SWEET CORN IN DOZENS OF EARS/ACRE.

	STARTER IRRIGATION	3 IRRIGATIONS	SMITHFIELD EXPERIMENTAL FARM
Sunny Vee	1300	1670	2410
Morning Sun	1270	1080	2270

The yield of sweet corn is less than that obtained at the Smithfield Experimental Farm. Plant population per row and row spacing are likely responsible for the difference.

(b) Moisture Consumption

Soil moisture use from the irrigation test plot was estimated from gravimetric sampling to be 14.1 inches (May 18 to Aug. 14) under irrigated conditions and from the Gen Atmometer at 11.9 inches. Under the moisture conditions in 1971, the moisture use from the corn receiving only starter irrigation would have been approximately the same.

D. Discussion

(a) Corn Production

Yield of sweet corn for market is related to the plant population to a great extent. Table XV indicates the plant populations found in the sample areas under the two treatments.

The analysis of variance indicated a very significant difference

TABLE XV PLANT POPULATIONS OF SWEET CORN 1971

SUNNY VEE		MORNING SUN	
Starter Irrigation	3 Irrigations	Starter Irrigation	3 Irrigations
161	189	196	142
157	193	178	98
154	169	131	127
143	170	142	111
148	173	102	94
129	179	139	127

for irrigation and corn variety. Even though seeding rate was supposed to be the same it is difficult to see how the same irrigation increased the plant population in one case and reduced it in the other by the same amount.

Since generally one ear of sweet corn is produced per plant, it is evident that a significant difference in yield should exist because of population differences. When the number of marketable ears was calculated per 1,000 plants, no significant difference was indicated for treatments or interaction between treatments; therefore, the difference in yield can be attributed to differences in plant population.

(b) Moisture Levels and Use

Tensiometers were not installed until June 5, but once installed were observed until early September when the vegetative crop was harvested. Figure VII shows the tensions recorded at the depths of one, two, and three feet. Soil moisture remained excellent until August, when both drought and rapid crop use of moisture began. The final irrigation beginning on July 22 brought the soil up to field capacity before the corn grew higher than the

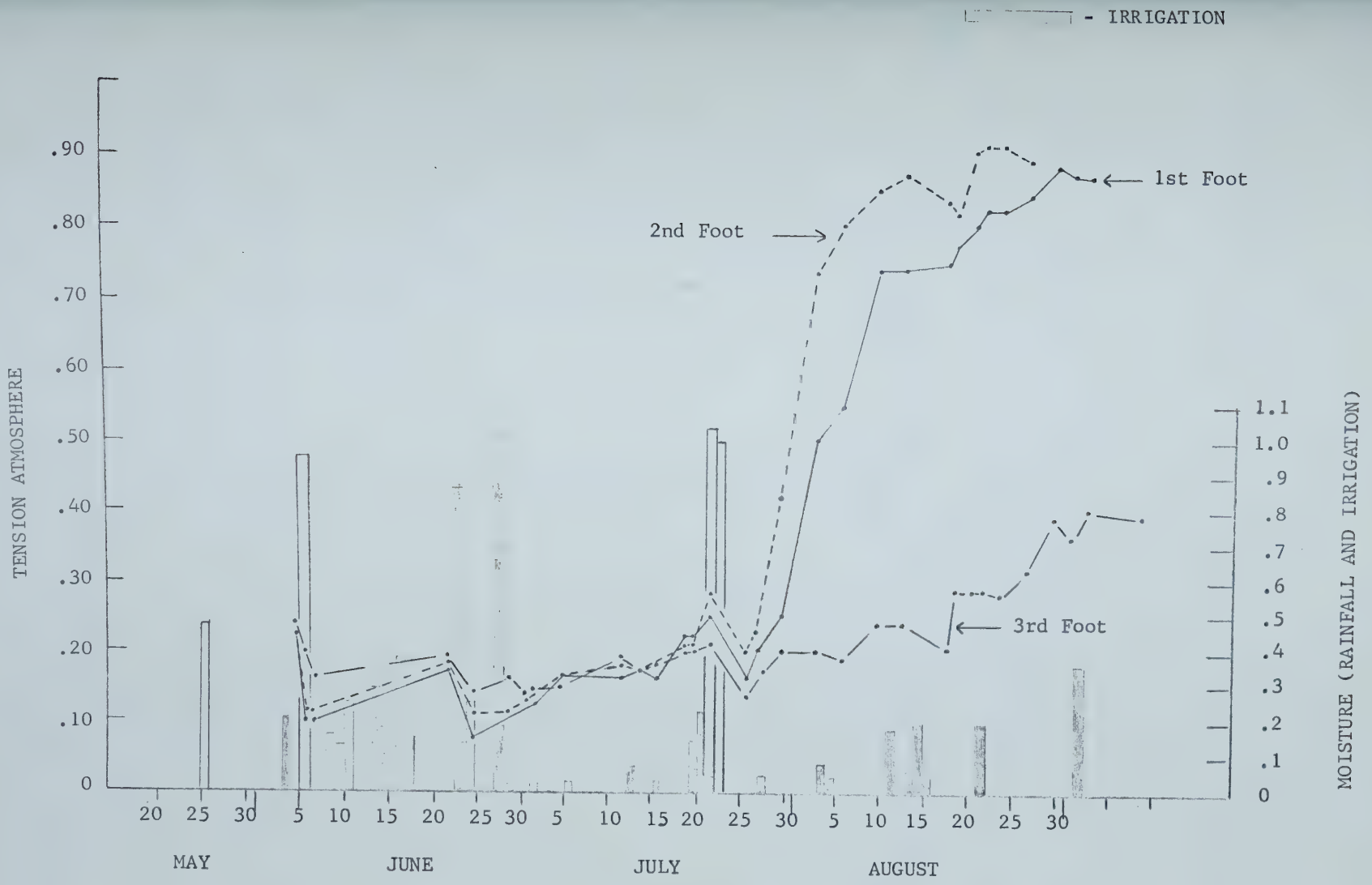

FIGURE VII: SOIL MOISTURE TENSION, IRRIGATION AND PRECIPITATION AT IRRIGATED SITE

the sprinkler risers. The lack of aggressive root system is indicated by corn's tendency to use the moisture from above the 3 foot tensiometer.

Table XV indicates the moisture use and rate of use as estimated from gravimetric soil sampling and as predicted from Gen Atmometer data.

TABLE XVI MOISTURE USE AND RATE OF USE BY SWEET CORN 1971

TIME PERIOD	ESTIMATED BY			
	GEN ATMOMETER		GRAVIMETRIC SOIL SAMPLES	
	Use inches	Rate of Use inches/day	Use inches	Rate of Use inches/ day
May 18 - July 3	2.39	0.05	3.37	0.07
July 3 - July 14	1.01	0.09	0.77	0.07
July 14- July 21	1.77	0.25	1.21	0.17
July 21- July 26	0.99	0.20	1.79	0.38
July 26- Aug. 6	1.61	0.15	2.78	0.25
Aug. 6 - Aug. 18	1.52	0.13	0.75	0.06
Aug. 18- Aug. 24	0.70	0.12	0.21	0.04
Aug. 24- Sept. 14	1.87	0.09	3.18	0.15
Total	11.86	0.10	14.06	0.12

The results show some variation, with the most consistent value obtained from the Gen Atmometer data. Soil sampling errors from the limited number of samples taken will produce more variation in use than the Gen Atmometer method does. Some difference in total use is noted but the variation to a large part can be attributed to soil sampling errors and the use of the same coefficients for calculating evapotranspiration from Gen Atmometer data as in Lethbridge. If corn moisture use is approximately 65% of that of alfalfa,*

*McCullock, A.W., J. Keller, R.M. Sherman and R.C. Mullen, Ames Irrigation Handbook for Irrigation Engineers.

then the results obtained appear to be correct. If alfalfa moisture consumption reaches 20 - 22 inches, this would indicate a moisture consumption by corn of 13 - 14 inches

(c) Frost Control

For the second year in a row, frost was not encountered in the important part of the growing season. This year frost did not occur until Labour Day Weekend (September 5 - 6) and it proved impossible to carry out frost control activities.

6. FALHER ALFALFA IRRIGATION PROJECT

A. Introduction

The investigation into increasing alfalfa production by irrigation in the Peace River Area was continued in 1971 at Falher. This work is being carried out with the assistance of the Falher Agricultural Service Board. The purpose of this project is to obtain an indication of the moisture demand in excess of natural precipitation, the timing of this demand, and the increases in yield and plant quality possible with irrigation. Some additional information concerning the irrigatability of the lacustrine soils found in this area can also be obtained.

B. Methods

(a) Study Site

The study site was moved from the 1970 location to a new site along Highway 2 just north of its junction with Highway 49 (Figure VIII). The move was considered necessary since the alfalfa stand at the new location was more uniform and the soil involved would be more representative of the major soil types in this area.

(b) Soil Characteristics

The majority of the soils in the immediate vicinity of Falher have developed on lacustrine deposits. In general they have excellent topography for irrigation and a degraded black soil profile exhibiting the properties of a solidized solenetz soil. The texture of the topsoil was clay loam and that of the subsoil, clay. The subsoil structure was massive and very firm, indicating restriction of moisture movement within the soil profile, (7).

Several soil samples were taken from the test area for the determination of suitability for irrigation and moisture holding capacities (Table XVII).

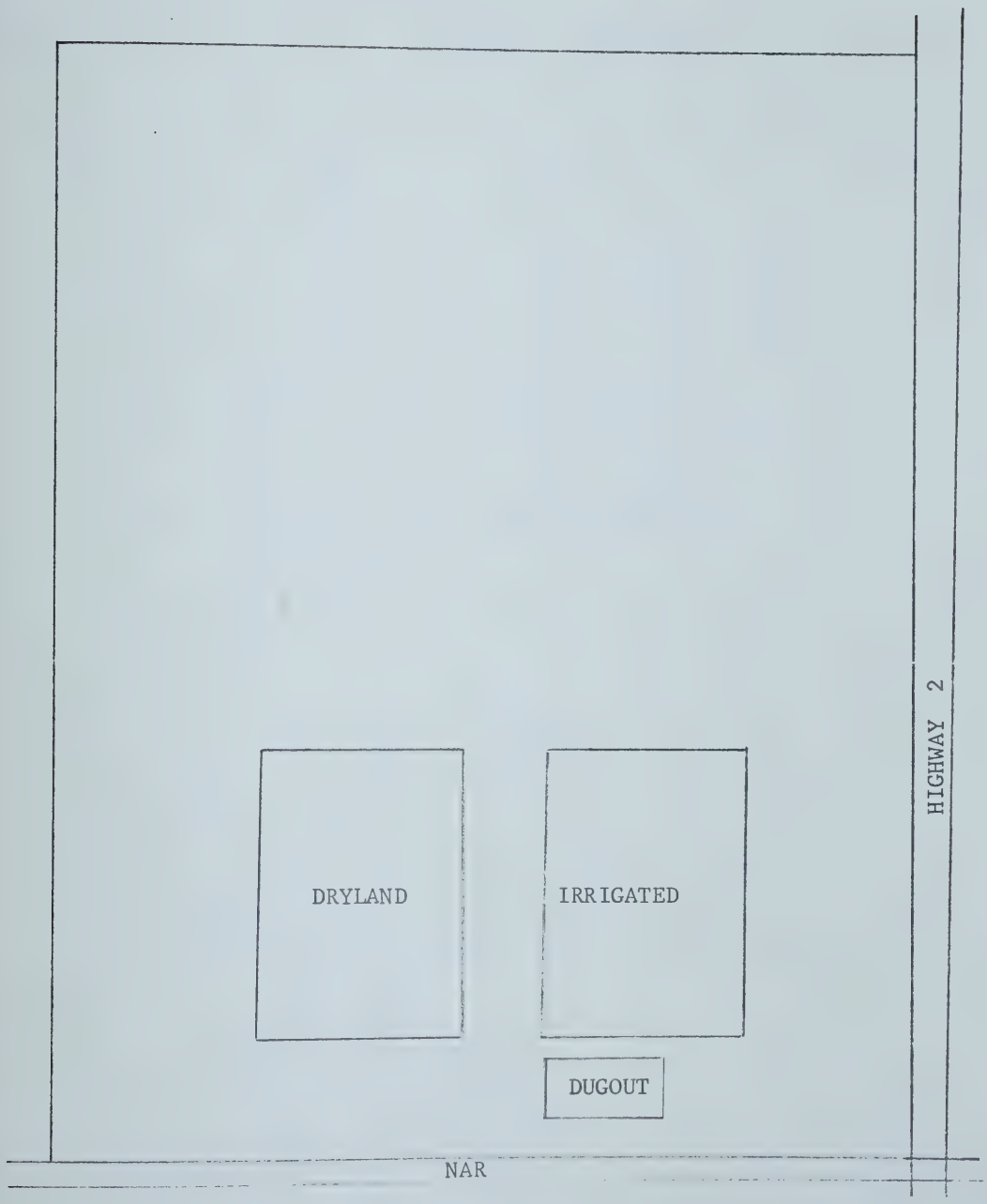

FIGURE VIII: FALHER ALFALFA IRRIGATION PROJECT SITE

TABLE XVII AVERAGE SOIL QUALITY AND MOISTURE HOLDING CAPACITIES

Depth of Soil Feet	pH	Electrical Conductivity millimho /centimeter	Sodium Adsorption ratio	Moisture Holding Capacities 1/3 Bar	15 Ba
0 - ½	6.5	0.8	0.9	37.3	18.2
½ - 1	6.7	1.1	2.0	38.0	21.3
1 - 2	7.7	1.2	3.5	42.4	21.4
2 - 3	7.6	2.0	5.3	42.6	23.9
3 - 4	7.4	4.3	4.7	40.0	22.7

(c) Water Supply and Irrigation Practices

Irrigation water was obtained from a farm dugout constructed by the Department of Highways. The dugout is filled by spring runoff from the surrounding area. The irrigation system was designed to use a 60 foot sprinkler move and a 40 foot sprinkler spacing. Four sets were used to provide full irrigation of 1.65 acres and partial irrigation of 0.52 acres. The first irrigation of 12 hour duration was carried out June 2 - 4 using an application rate of 0.17 in./hr (9/64 nozzles). The second irrigation of nine hour duration was carried out between August 3 and 5 applying water at the rate of 0.29 in./hr (3/16 inch nozzles).

(d) Crop Management Practices

The crop was managed in such a manner as to make the production of a second cut possible. The first cut was harvested on July 16 and the second on August 18. One hundred lbs/acre of 11-48-0 fertilizer were applied to both irrigated and non-irrigated treatments after the first crop had been harvested. A composite sample was prepared by taking a core of forage from eight different bales.

(e) Soil Moisture Measurements

Gravimetric soil moisture samples from the depths 0-1, 1-2, 2-3, and 3-4 feet were taken as regularly as possilbe after June 24 until September 14 from both irrigated and non-irrigated areas. Tensiometers were installed at the depths of one and two feet on the irrigated area June 24 and later in the non-irrigated area, and the results were recorded September 14. The gravimetric soil samples were taken from an area approximately 25 feet in diameter surrounding the tensiometer sites.

Rainfall data was obtained from Mr. Lemire who maintains a rain gauge for the Ministry of Transport. The data was recorded daily.

C. Results

(a) Alfalfa Production

Irrigation increased yield but to a lesser extent than expected (Table XVIII).

TABLE XVIII YIELD OF ALFALFA HAY 1971

	Irrigated Treatment ton/acre	Non-irrigated Treatment ton/acre
1st Cut	1.05	0.94
2nd Cut	1.07	0.68
Total	2.12	1.62

If the second cut of hay had been delayed until later, the increase in alfalfa would have been greater since the better moisture conditions on the irrigated land would have increased the difference (see Figures IX a and b). A later harvest date would also have reduced quality. The laboratory analyses to determine hay quality are given in Table XIX.

TABLE XIX LABORATORY ANALYSIS OF ALFALFA HAY FOR QUALITY EXPRESSED AS PERCENT

FACTOR	1st Cut		2nd Cut	
	Irrigated	Non-Irrigated	Irrigated	Non-irrigated
% leaves[1]	44.50	42.70	56.60	51.00
% protein[2]	15.50	16.40	21.70	18.00
% fiber[2]	32.00	33.90	25.10	29.20
% calcium[2]	1.12	1.08	1.60	1.21
% phosphorus[2]	0.22	0.23	0.23	0.30
% nitrate[2]	0.53	0.46	0.00	0.40
% O.M.D.[1]	-	-	69.20	68.90

[1] percent wet weight
[2] percent dry weight

In this case, irrigation increased the percentage of leaves and calcium but decreased fiber content. However, irrigation decreased percent protein in the first harvest but increased it in the second harvest. These differences in part are likely related to other conditions such as time of rainfall and cutting date as well as irrigation.

The irrigation applied in early June was much too late to have a full effect on the first harvest. The original irrigation test site (1970) had a better spring moisture level and irrigation was not considered to be necessary until late May. The change in location altered these calculations and irrigation at this site was required immediately but unfortunately was not possible. In early June, alfalfa at the new site was four to five inches in height and flowering had begun.

(b) Moisture Requirements

It is considered that irrigation in the 1971 growing was insufficient

to obtain optimum growth. Scheduling was also badly handled during May and growth was inhibited by the lack of moisture. From gravimetric soil sampling, rainfall, and Gen Atmometer data, the following estimations of moisture requirements for irrigated and non-irrigated alfalfa were made (Table XX).

TABLE XX MOISTURE USE BY ALFALFA 1971

PERIOD	GEN ATMOMETER INCHES	NON-IRRIGATED USE INCHES OF WATER	IRRIGATED USE INCHES OF WATER
May 1 - Sept. 30		11.0 est.	16.5 est.
May 23- Sept. 14	18.8		
June 24 - Sept. 14	14.3	7.00 inches	11.6

These results indicated, as suspected, that actual moisture provided by irrigation was not adequate to prevent crop loss from moisture stress.

(c) Soil Moisture Infiltration

It was evident that the soil in the test plot would accept 0.16 in./hr moisture gross application rate but not a gross application as great as 0.29 in./hr. without ponding. During the rainy June - July period it became evident that internal movement of soil moisture was restricted by the internal structure of the subsoil.

D. Discussions

(a) Alfalfa Production

Table XXI compares the precipitation received in 1971 with the 1930 - 1960 averages recorded for Fairview.

This above-normal rainfall can be expected to produce above average forage crops, particularly since most of it occurred in June and July thus

reducing the possible benefits from irrigation. Better irrigation scheduling durin May would have resulted in better use of the available growing season and have increased yield beyond that actually obtained in 1971 with poor irrigation scheduling.

TABLE XXI COMPARISON OF PRECIPITATION FOR 1971 AND THE 1931 - 1960 FAIRVIEW AVERAGE

Month	1971 Precipitation inches	1931-1960 Precipitation inches	Difference
May	0.67	1.43	- 0.76
June	5.25	2.33	+ 2.76
July	3.09	2.55	+ 0.54
Aug.	1.89	1.96	- 0.07
Sept.	NA	1.34	NA
Total		9.61	

(b) Soil Moisture Levels and Use

The recorded rainfall, applied irrigation, and tensiometer readings for the depths of one and two feet are indicated for both irrigated and non-irrigated treatments in Figures IX a and b. The results do not cover the dry period from early May until mid June. It is also anticipated that under normal conditions, tensiometers would not have proved an effective means of tracing soil moisture during most of the season. Through the period monitored by the tensiometers, moisture was more readily available on the irrigated plot than the dryland area, although moisture to the depth of two feet must be considered adequate in both treatment areas.

In Table XXII several estimates of rate of moisture consumption are made from available data from the Gen Atmometer* and from gravimetric moisture determination.

* Agrohydrology Section

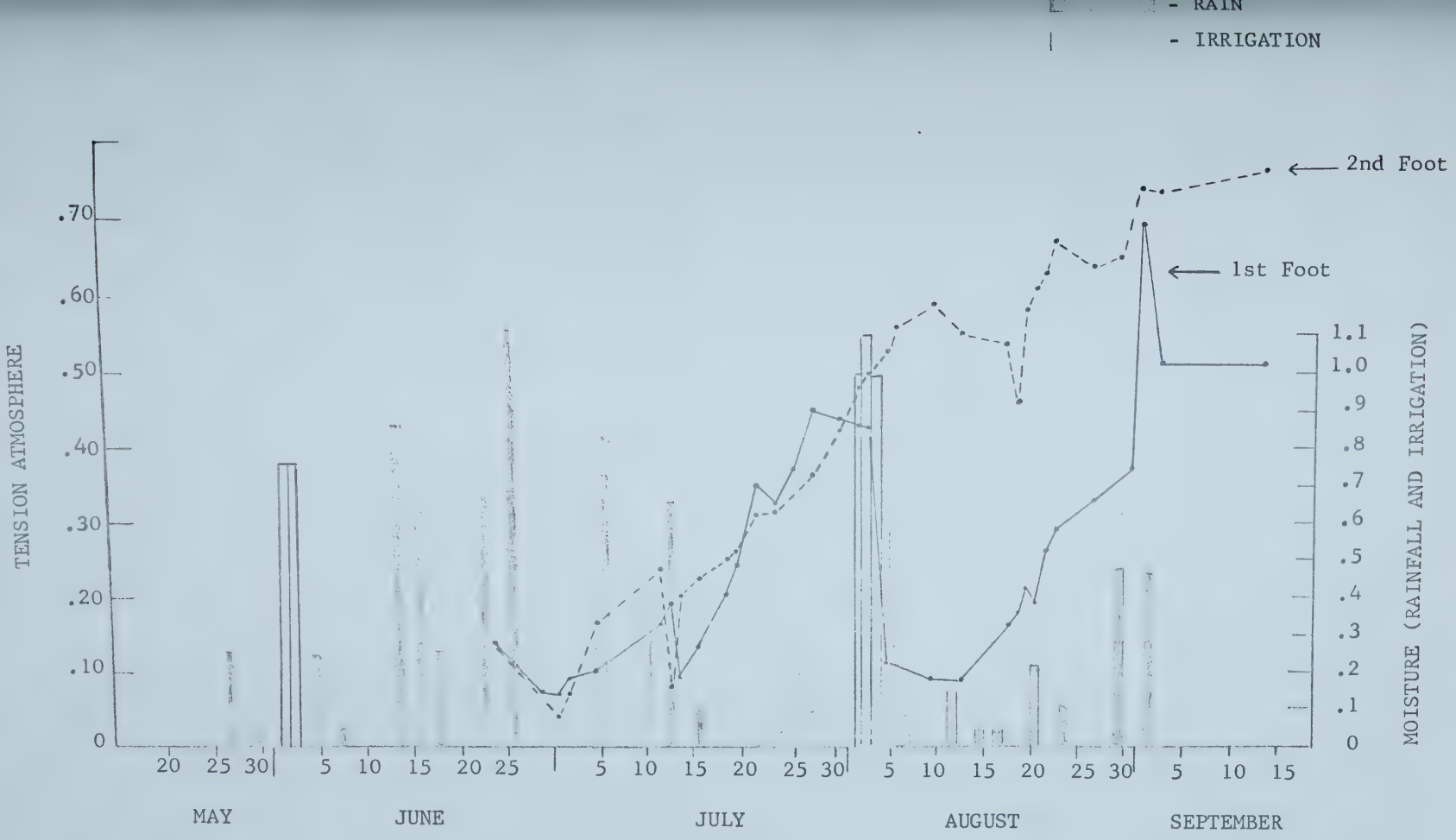

FIGURE IX a: SOIL MOISTURE TENSION, IRRIGATION AND PRECIPITATION, IRRIGATED SITE

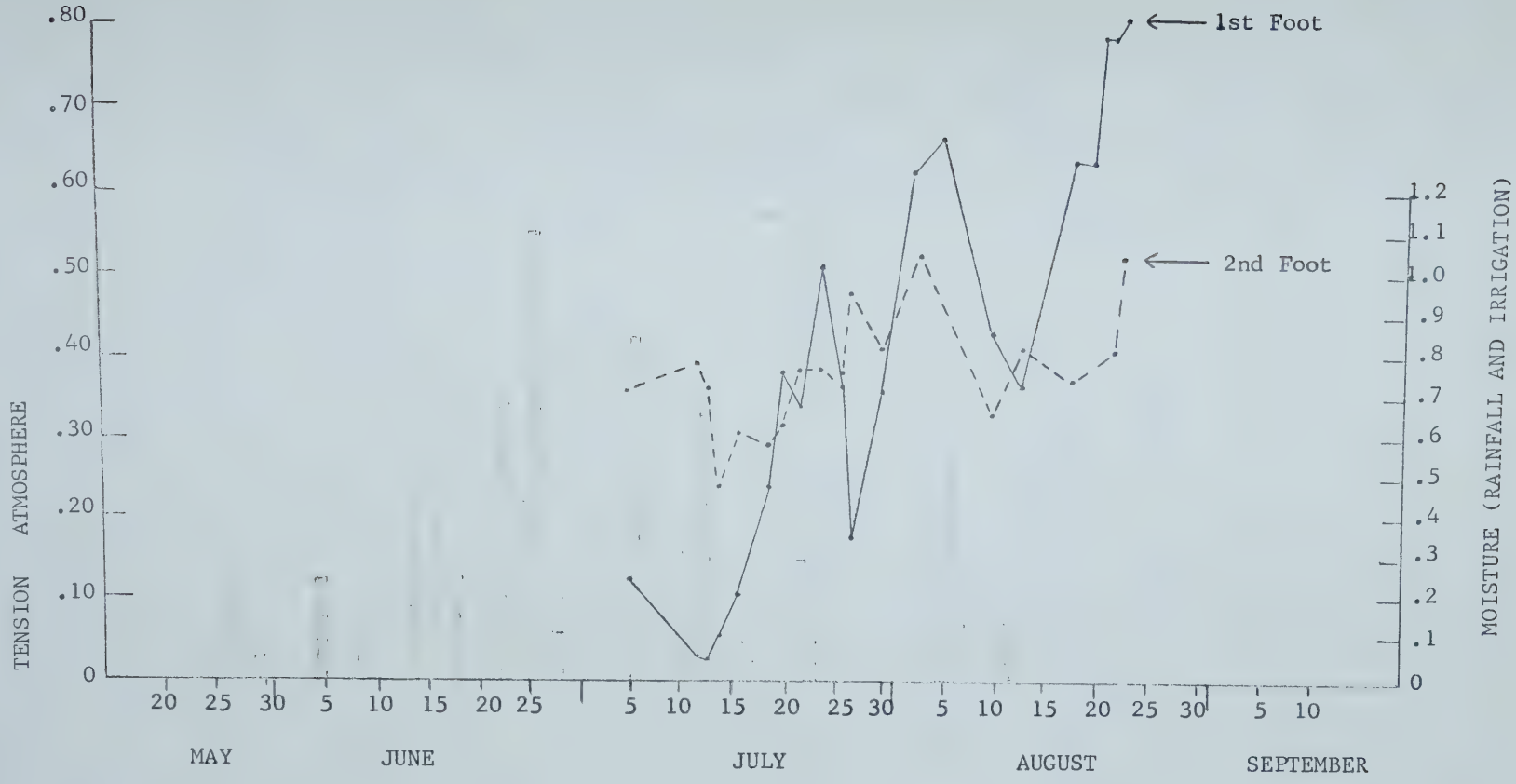

FIGURE IX b: SOIL MOISTURE TENSION, PRECIPITATION, NON-IRRIGATED SITE

TABLE XXII RATE OF MOISTURE USE BY ALFALFA 1971

PERIOD	GEN ATMOMETER		GRAVIMETRIC MOISTURE IRRIGATED ALFALFA		NON-IRRIGATED ALFALFA	
	Moisture Use inches of water	Inch/day	Moisture Used inches of water	Inch/day	Moisture Used inches of water	Inch/day
May 1 - June 24	4.61 (May 18-June 24)	0.13	5.03	0.09 est.	3.53	0.06
June 24 - July 2	0.58	0.07	1.43	0.18	0.49	0.06
July 2 - July 13	1.62	0.16	0.81	0.08	0.00	0.00
July 13 - July 22	1.96	0.20	2.49	0.27	0.36	0.04
July 22 - July 26	0.42	0.10	1.04	0.26	1.52	0.38
July 26 - Aug. 18	4.78	0.21	3.46	0.16	3.07	0.14
Aug. 18 - Aug. 23	1.23	0.21	0.84	0.17	0.68	0.14
Aug. 23 - Sept. 14	4.00	0.19	1.49	0.07	0.78	0.04
TOTAL	18.81	0.17	16.59	0.12	10.43	0.08

Gravimetric soil moisture sampling produced results having more variation than those calculated from Gen Atmometer evaporation. The total moisture use as measured indicates an under-irrigation of the alfalfa. A closer look indicates that the Gen Atmometer indicated moisture use is 10.2 inches and that of gravimetric 10.6 inches from June 24 until August 23 when the second harvest was completed. As expected, the moisture consumption from the non-irrigated area was more variable than from the irrigated area.

(c) Moisture Infiltration

This particular lacustrine soil appears to exhibit a limited infiltration rate. Little trouble was encountered with a 0.16 in./hr application rate but ponding occurred when the higher rate of 0.29 in./hr was applied. If the lower application of water was great enough to bring the topsoil to the 1/3 bar moisture level topsoil saturation and surface ponding was noted. This indicates an even less permeable subsoil. These factors will limit the potential use of this soil for irrigation purposes. Further work to determine permeability would be recommended if "serious irrigation" was to be considered.

7. CONCLUSIONS

Irrigation can increase yield of alfalfa when normal or slightly above-normal precipitation is received. The timing of rainfall is quite critical. In at least three cases, Oliver Plots 1970, 1971 and Falher 1971, alfalfa reached the flowering stage at a height of 4 or 5 inches in early June, before sufficient moisture was received. In each case after receiving rain, the alfalfa recovered and made rapid growth and the difference in hay yield was much less than expected during early June. This is likely related to the fact that moisture use and growth may be fairly constant until a definite level of moisture stress is reached.[8]

Irrigation scheduling appeared to be quite important in obtaining the best yield with the least use of irrigation. In the Central Alberta and Peace River areas it appears necessary to consider the chance of receiving adequate levels of rain fall during the next week and adjust irrigation scheduling and size of irrigation with reference to risk analysis. During 1970 and 1971, this use of Risk Analysis of Weekly Climatic Data for Agricultural and Irrigation Planning[2] combined with soil moisture measurements proved successful in predicting irrigation demnds at the Oliver Alfalfa Plots (1).

In dealing with specialty crops such as vegetables, irrigation appeared to be required for insurance against crop loss. Irrigation speeds germination and gives uniform stands of crop and finally can prevent drought stress during the critical periods for crop growth and quality maintenance.

Total costs of operating and maintaining sprinkler systems (either hand move or wheel move) have been estimated during spinkler design as between $20 and $30 per acre[5]. Since most farmers using these systems generally cover more acreage than the system was originally designed for, the cost of operation would decrease slightly. Since the average hay yield for Edmonton is estimated

at 1.91 ton/acre* and irrigated alfalfa for 1970 and 1971 at 4.4 ton/acre, some advantage appears to result from irrigation. Hay quality had been variable. Literature seems to support this view and indicates variation in moisture level and irrigation timing relative to soil moisture level plays a part in determining forage quality. In 1964, Brezeau and Sommer showed that the nutritive value of alfalfa was influenced by irrigation timing. Alfalfa was irrigated after 25%, 50% and 75% soil moisture depletion. Irrigation after the 50% level of moisture depletion produced more digestible cellulose than either of the other two levels. Another study also found moisture did not affect crude protein consistently in the same way and that alfalfa grown under high moisture stress yielded less dry matter but a greater percentage of leaves, higher in vitro digestibility than that grown under more favorable conditions. The results for the alfalfa in this study vary from those indicated in the literature but the mechanical operation of baling might in some cases affect the leaf matter.

It has been noted that alfalfa stand deterioration has been more rapid under irrigated than non-irrigated conditions. This deterioration has been mainly from winter kill rather than ivasion by other species. Ths winter kill is likely related to the additional plant growth under irrigated conditions after the second cut of alfalfa has been made.

Irrigation will generally be required most often during May and early June and during late August.

* Alberta Department of Agriculture Economics Divison, in co-operation with the Dominion Bureau of Statistics. Agricultural Statistics.

8. FUTURE NEEDS

It is hoped that future evaluation will continue to obtain additional information about the potential and limitations of irrigation. The specific areas of interest remain:

1) The increase in yield and quality of this yield possible with irrigation

2) The value of irrigation in permitting diversification in crops and cropping practices

3) The sceduling of irrigation, involving when possible "Risk Analysis" techniques

4) The irrigation needs and distribution of these needs both within a single season and over a period of seasons.

9. LITERATURE CITED

1) Brezeau, L.M. and L.G. Sommer. "The Influence of levels of Irrigation on the Nutritive Value of Alfalfa." Can. Journ. Plant Sci., 44, 505-508.

2) Canada Department of Agriculture Agrometeorological Section. Risk Analysis of Weekly Climatic Data for Agriculture and Irrigation Planning, Edmonton, Alberta.

3) Chapman, L.J. and Bromn, D.M. The Climates of Canada for Agriculture. The Canada Land Inventory. Report No. 3, 1966.

4) Davies, F.D. Evapotranspiration / Evaporation Ratio for Northern Alberta. Alberta Department of Agriculture, Water Resources Division. February, 1971.

5) Gubbels, G.H. "Frost Protection of Crops by Sprinkler Irrigation". Can. Jour. Plant Sci., 49, 715 - 718.

6) Heywood, R.T. and D.G. Harrington. "Irrigation: Alberta Parkland." Paper presented C.S.A.E. Conference, July 6, 1971.

7) Odynsky, W.M. and J.D. Newton. Soil Survey of the Rycroft and Wateno Sheets. Alberta Soil Survey, Report No. 15, 1930.

8) Shayhewich, C.E. and B.P. Workentin. "Effect of Clay Content and Aggregate Size on Availability of Soil Water to Tomato Plants." Can. Jour. Soil Sci., 50 (June, 1970) 205 - 217.

9) Vough, L.R. and C.C. Martin. "Influence of Soil Moisture and Ambient Temperature on Yield and Quality of Alfalfa Forage." Agronomy Journal, 63. (June - February, 1971), 40 - 42.